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ABSTRACT

Students in an introductory statistics course are often preoccupied with learning the computational routines of specific summary statistics and thereby fail to develop an understanding of the meaning of those statistics or their conceptual basis. To help students develop a better understanding of the meaning of three frequently used statistics, this document presents HyperCard programs and a Lotus 1-2-3 spreadsheet for use by teachers in classroom simulation demonstrations of Pearson's correlation coefficients, t-test of two independent population means, and one-way analysis of variance. The instructional contents and typical computer screen outputs for each demonstration are discussed in association with their respective HyperCard programs, which are included in the appendix. (JJK)

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*Teaching the Meaning of
Statistical Techniques with
Microcomputer Simulation*

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TEACHING THE MEANING OF STATISTICAL TECHNIQUES WITH MICROCOMPUTER SIMULATION

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Students in an introductory statistics course are often preoccupied with learning the computational routines of statistics without fully understanding the meaning of statistics. We created a HyperCard stack and a LOTUS 1-2-3 spreadsheet to be used by instructors (our intended users) in helping students develop a better understanding of the meaning of frequently used statistics. Intentionally, we have made the appearance and operation of the HyperCard stack and the 1-2-3 spreadsheet similar. We will discuss the instructional content and the programming techniques by comparing the approaches we used with HyperCard and LOTUS 1-2-3

Instructional Contents

The stack contains "demos" for three statistics: Pearson's correlation coefficients, t-test of two independent population means, and one-way analysis of variance. The simulations were designed to be displayed on a projection screen using a transmissive (overhead) projector. Our goals were to keep the text large enough to be read from the back of a classroom and to keep the display simple enough to be used as an effective visual aid. Each statistical analysis was kept simple by imposing certain restrictions in addition to the theoretical assumptions of the statistics.

The instructor can move from one topic to another by clicking the buttons on the cards or and on the stack "map" (Figure 1). In Lotus 1-2-3, a macro driven menu is used to select the topics. A "talk"

button shaped like a face is used to call the narrative cards and a "demo" button is used to call the cards where the demos begin.

The first demo of Pearson's correlation coefficients (Figure 2), shows the consequences of violating the linearity assumption. The Y-values (shown in the box) can be changed to create outlier(s) or perfect but nonlinear relationships such as quadratic. (In 1-2-3, the cells for the Y-values are unprotected and therefore highlighted.) Clicking the "calc" button, recalculates a new set of output values. To simplify the graphic presentation, we kept the X-variable fixed. The "graph" button (F10 key for 1-2-3 file) displays the graph (Figure 3) of the two variables and a "return" arrow toggles back to the data set.

In the first demo of Pearson's correlation coefficients, the conclusion is hidden from view. This was done so that the students will have a chance to draw their own conclusion about the test of significance before it is displayed on the screen. The "conclusion" button (the ALT-C macro for 1-2-3) displays the conclusion and the "hide conclusion" button hides it again. In the other demos, the conclusion appears automatically when the calc button is clicked. The computational formulas and the significance table are hidden. The "?" button displays the formulas and some computational details (Figure 4). In 1-2-3, some of the formulas are shown on-screen with the demo. Others are off-screen but can be displayed by paging down to the range of cells below the demo screen.

The second demo of Pearson's correlation coefficients (Figure 5), shows the effects of sample size on the significance of a computed r value. Students often equate significance with the strength of correlation. This demo can be used to demonstrate that even a small r -value can be significant if the sample size is large and that the same r -value may not be significant if the sample size is small. The "table" button displays the significance table (Figure 6). In 1-2-3, the significance table can be displayed by tabbing to the next range of cells to the right of the demo screen.

The demo for t -test (Figure 7) shows the effects of sample sizes, sample means and sample variances on the computed t -value and its significance. With the t -test demo, the instructor can show students

the importance of differentiating between the 1-tail and 2-tail tests. For this purpose, we simplified the significance table by creating only two columns, one for the 1-tail test and the other for the 2-tail test both at .05 level. The instructor can demonstrate the outcome of choosing 1-tail test or 2-tail test for a given computed t-value. This should help the students understand the importance of having a hypothesis formulated directionally, whenever there is a theoretical basis to do so.

The demo for one way analysis of variance (Figure 8) can be used to help the students learn how to plan the orthogonal comparisons, and how to read the ANOVA table. The first part of the demo (Figure 8), shows how the changes in data affect the statistics. The second part of the demo, which appears upon a click of the "hand" button, can be used in testing the hypotheses for the locations of differences among the means.

Program Contents

With HyperCard, computations are conducted with the use of named fields and variables using HyperTalk. The values placed in the named fields (for example the Y-values shown in Figure 2) are placed in named variables, and the named variables are placed in the computational formulas. The computed results are then returned to the named fields as results. The card script for a given card contains the program for that card and possibly for auxiliary cards. Card Script 1, for example, shows the program written for the first card of the first demo of Pearson's correlation coefficients.

Card Script 2 shows the the program for the graphing routine used to display an X-Y plot (Figure 3) of the data used for the first demo of Pearson's correlation coefficients. Briefly, the routine used operates as follows:

1. The Y-values are sorted to determine the maximum and minimum Y-values.

2. The difference between the values is used to scale the values shown along the Y-axis of the graph and to determine a "scale" factor for the graph.

3. The scale factor is used to compute the Y-coordinates plotted on the graph. The X-coordinates progress at a regular interval of 40 pixels per plotted point.

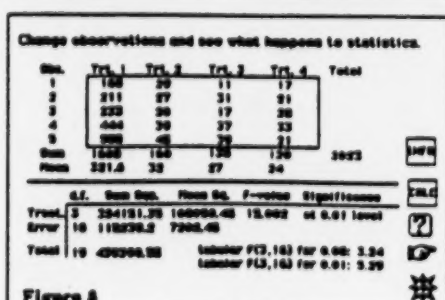
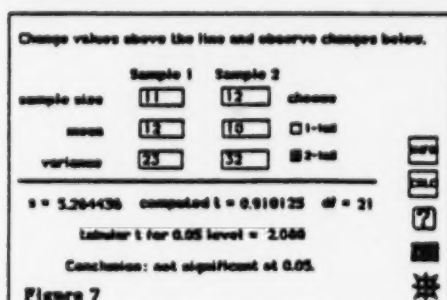
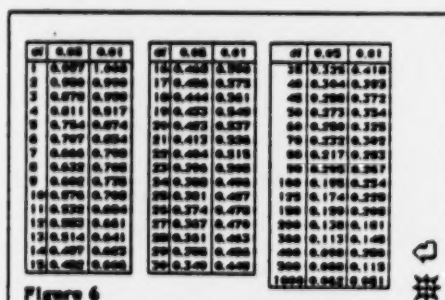
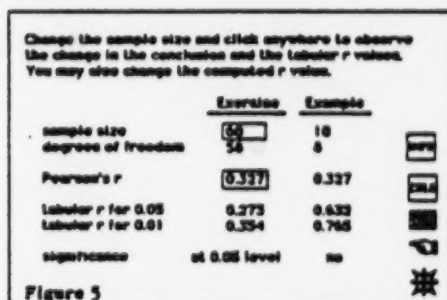
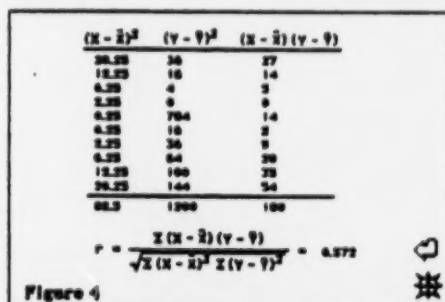
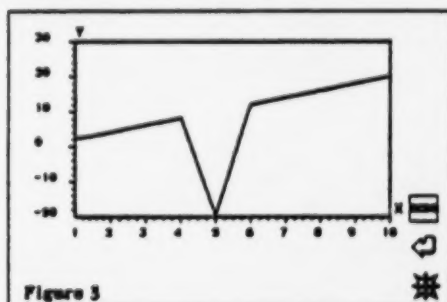
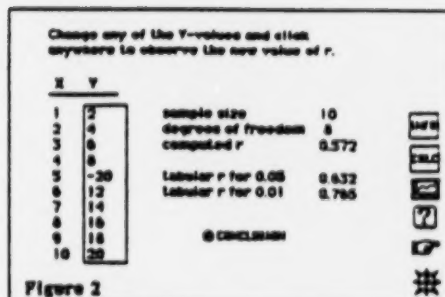
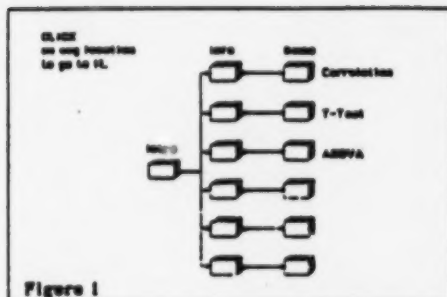
A "table lookup" routine was used in the second demo of Pearson's correlation coefficients (Figure 4) to determine the tabular r-values based on the degrees of freedom. The value found in the table is returned as the computed r-value. Briefly, the lookup routine operates as follows:

1. First the value for degrees of freedom is computed and placed in the variable, deg. The value in deg is used to identify the line number (n) and column numbers (j and k) in the significance table (Figure 5.) from which the r-values should be copied.
2. The table is divided into three parts with three columns in each part (one for the degrees of freedom and one for each level level of significance). The value of deg can be used to determine the line number (n) and the field numbers for the .05 and .01 levels (j and k, respectively). If the value of deg is less than 16, for example, the value of n will be equal to deg, j will be equal to 2 and k will be equal to 3.
3. The r-values are then copied from the nth line of the jth card field and the nth line of the kth card field to the designated locations (Figure 2).
4. Then, the computed r-value is copied into the variable "rval", which will be compared against the two tabular values to determine whether it is significant at .05 or .01 level. As a result of this comparison, the conclusion statement is copied into the global variable "it". The selected conclusion is then copied into the designated location (Figure 5).

The lookup routine for t-test operates in a similar manner to identify the tabular values at .05 level for 1-tail and 2-tail tests., and returns a value (Figure 6), depending upon the user's choice between 1-tail and 2-tail.

The program for ANOVA basically operates in similar manner to the other computational procedures used in the previous two topics. In the ANOVA demonstration, we used the fixed degrees of freedom for F-values, so no lookup routine was needed.

The availability of `@vlookup` and `@if` functions in 1-2-3 makes programming with 1-2-3 quite simple. All the computational formulas are placed in the cells where statistics appear. The significance table which is used to determine the tabular values with LOTUS 1-2-3, is placed off screen so that it is hidden from view. An `@vlookup` function with the criterion being the degree of freedom is imbedded in the cells where tabular values appear for the given degrees of freedom. An `@if` function is used to identify the correct conclusion by comparing the computed value against the tabular values. The conclusion is copied to the conclusion cell in each of the demos except for the first demo for Pearson's correlation coefficients. In that demo, an ALT-C macro is used to hide the conclusion until the students have been given a chance to decide what the correct conclusion should be. The macro is located in the range immediately below the home screen where other commands have been hidden.



doMenu "Clear Picture"
 choose line tool
 set linesize to 2
 repeat with n-2 to 10
 put xval2 into xval1
 put value of (xval1 + 40) into xval2
 put yval2 into yval1
 put line n of card field 2 of card id 3831 into it
 subtract ymin from it
 put value of (237 - (trunc(8*it/scale))) into yval2
 drag from xval1,yval1 to xval2,yval2
 end repeat
 set linesize to 1
 choose browse tool
 end mouseUp

Card Script 3

on mouseUp
 put line 1 of card field 1 into deg
 subtract 2 from deg
 put deg into line 1 of card field 2
 if deg >= 1 then
 put deg into n
 put 2 into j
 put 3 into k
 if deg >= 16 then
 put value (deg - 15) into n
 put 5 into j
 put 6 into k
 if deg >= 30 then
 put 15 into n
 if deg >= 35 then
 put value of (-6 + trunc(2*deg/10)) into n

put 8 into j
 put 9 into k
 if deg >= 50 then
 put value of (-1 + trunc(deg/10)) into n
 if deg >= 100 then
 put value of (5 + trunc(4*deg/100)) into n
 if deg >= 125 then put 10 into n
 if deg >= 150 then put 11 into n
 if deg >= 200 then
 put value of (10 + trunc(deg/100)) into n
 if deg >= 500 then put 15 into n
 if deg >= 1000 then put 16 into n
 end if
 end if
 end if
 end if
 end if
 end if
 put line n of card field j of card id 5329 into val1
 put val1 into line 1 of card field 4
 put line n of card field k of card id 5329 into val2
 put val2 into line 2 of card field 4
 put line 1 of card field 3 into rval
 put " no" into it
 if rval > val1 then put "at 0.05 level" into it
 if rval > val2 then put "at 0.01 level" into it
 put it into line 1 of card field 5
 end mouseUp

Card Script 1

```

on mouseUp
  put 5.5 into xavg
  put 0 into yavg
  repeat with n-1 to 10
    put line n of card field 2 into yval
    add yval to yavg
  end repeat
  divide yavg by 10
  put 0 into ysum
  put 0 into xysum
  repeat with n-1 to 10
    put line n of card field 1 into xvar
    subtract xavg from xvar
    put line n of card field 2 into yvar
    subtract yavg from yvar
    put value of (xvar*yvar) into xyvar
    put value of (yvar^2) into yvar
    put yvar into line n of card field 2 of card id 4218
    put xyvar into line n of card field 3 of card id 4218
    add xyvar to xysum
    add yvar to ysum
  end repeat
  put ysum into line 1 of card field 5 of card id 4218
  put xysum into line 1 of card field 6 of card id 4218
  put value of (xysum/sqrt(82.5*ysum)) into rval
  put rval into line 1 of card field 4
  put rval into line 1 of card field 7 of card id 4218
  if rval>0.765 then put "significant at 0.01 level" into
conc
  else
    if rval>0.632 then put "significant at 0.05 level" into
conc

```

```

else
  put "not significant" into conc
end if
end if
put conc into line 1 of card field 6
end mouseUp

```

Card Script 2

```

on mouseUp
  put line 1 of card field 2 of card id 3831 into ymin
  put ymin into ymax
  repeat with n-1 to 10
    put line n of card field 2 of card id 3831 into yval
    if yval < ymin then put yval into ymin
    if yval > ymax then put yval into ymax
  end repeat
  put ymax into yval
  subtract ymin from yval
  divide yval by 25
  put value of (trunc(yval) + 1) into yval
  put yval into scale
  multiply yval by 5
  put ymin into it
  repeat with n-1 to 6
    put it into card field n
    add yval to it
  end repeat
  put 86 into xval2
  put line 1 of card field 2 of card id 3831 into it
  subtract ymin from it
  put value of (237 - (trunc(8*it/scale))) into yval2
  choose select tool
  drag from 86,39 to 444,236

```